

# SHRUB AND GRASS LAND ECOSYSTEM WATER USE EFFICIENCY ON WGEW

RISE SYMPOSIUM 2005

by

WILLIAM E. EMMERICH

USDA-ARS

SOUTHWEST WATERSHED RESEARCH CENTER

TUCSON, AZ



# WATER USE EFFICIENCY

- Definition: Amount of carbon uptake per amount of water use.



# WATER USE EFFICIENCY

## Plant Water Use Efficiency

- $C_3$   $C_4$  CAM



# WATER USE EFFICIENCY

## Ecosystem Water Use Efficiency

- Plants - Structure







# WATER USE EFFICIENCY

## Ecosystem Water Use Efficiency

- Soils - Infiltration, Water holding capacity, Surface cover















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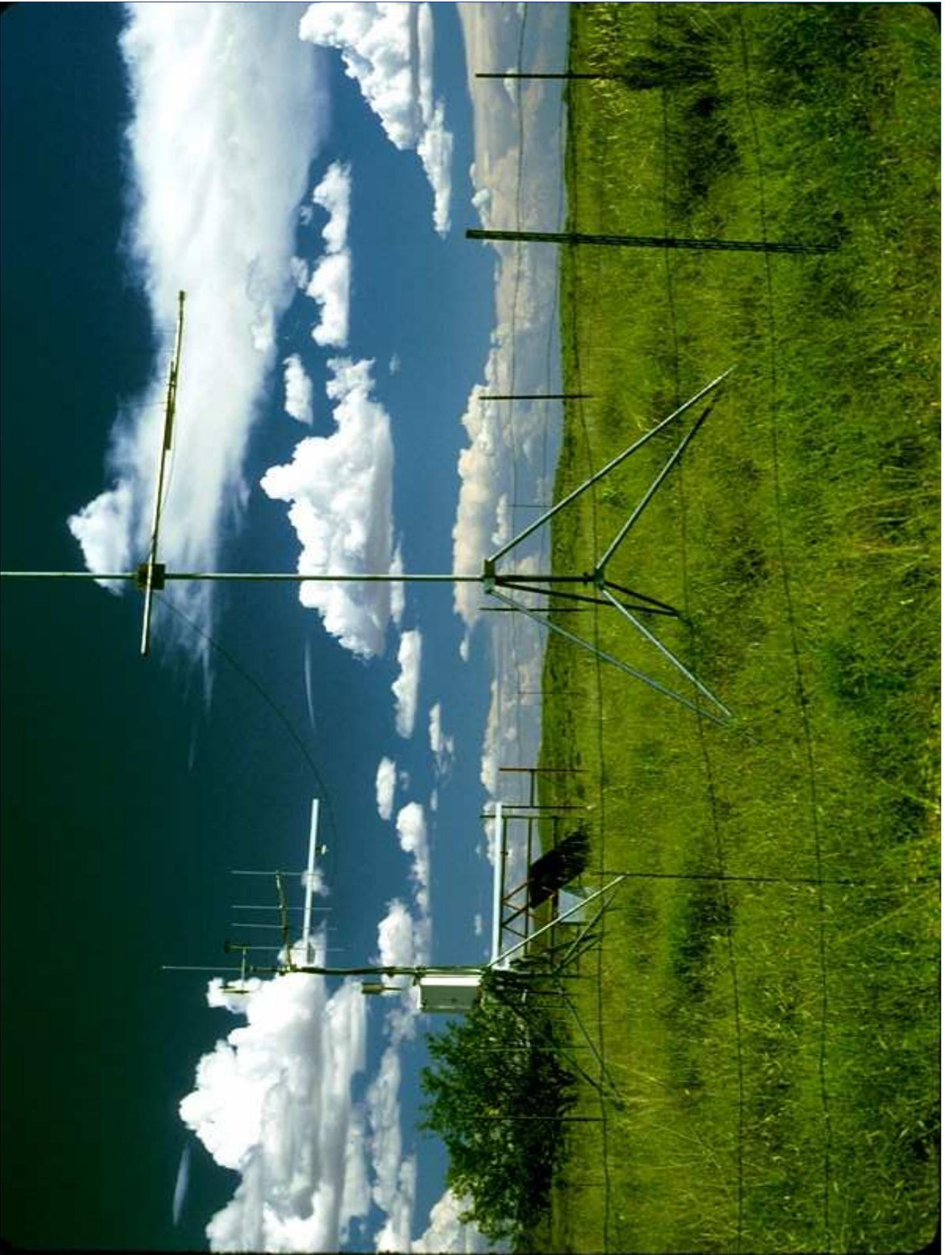
# EVALUATION OF ECOSYSTEM WATER USE EFFICIENCY

Measure Carbon and Water Fluxes.

- Bowen Ratio Systems
- Aboveground Biomass Sampling
- Belowground Biomass Estimates







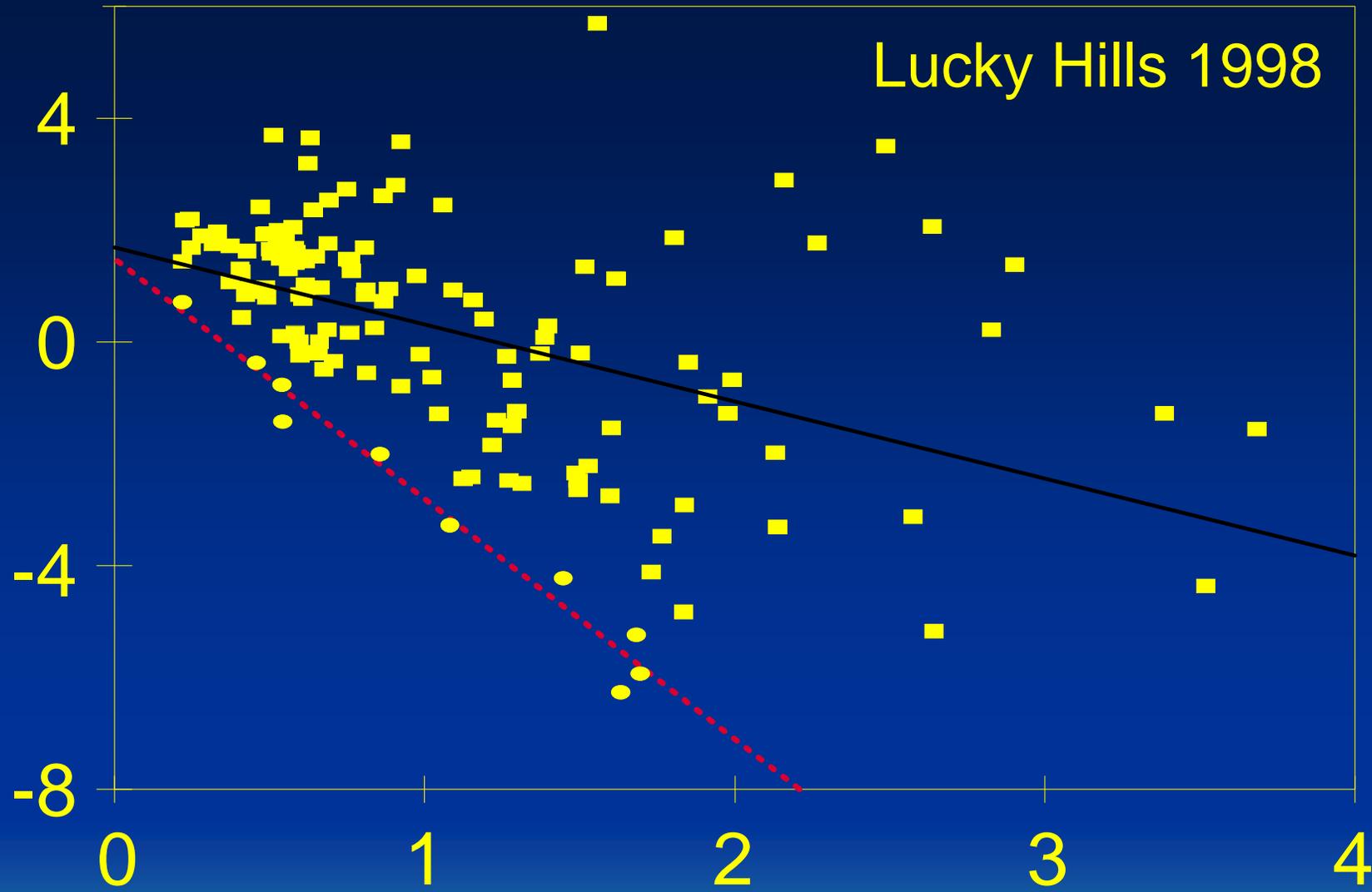
# ECOSYSTEM WATER USE EFFICIENCY EVALUATION PROCEDURES

- Regression Slope for Daytime  $\text{CO}_2$  Flux vs ET.
- Regression Slope for Maximum  $\text{CO}_2$  Flux vs Minimum ET.
- Ratio of  $\text{CO}_2$  Flux to ET.
- Measured and Estimated Biomass Production Divided by ET.



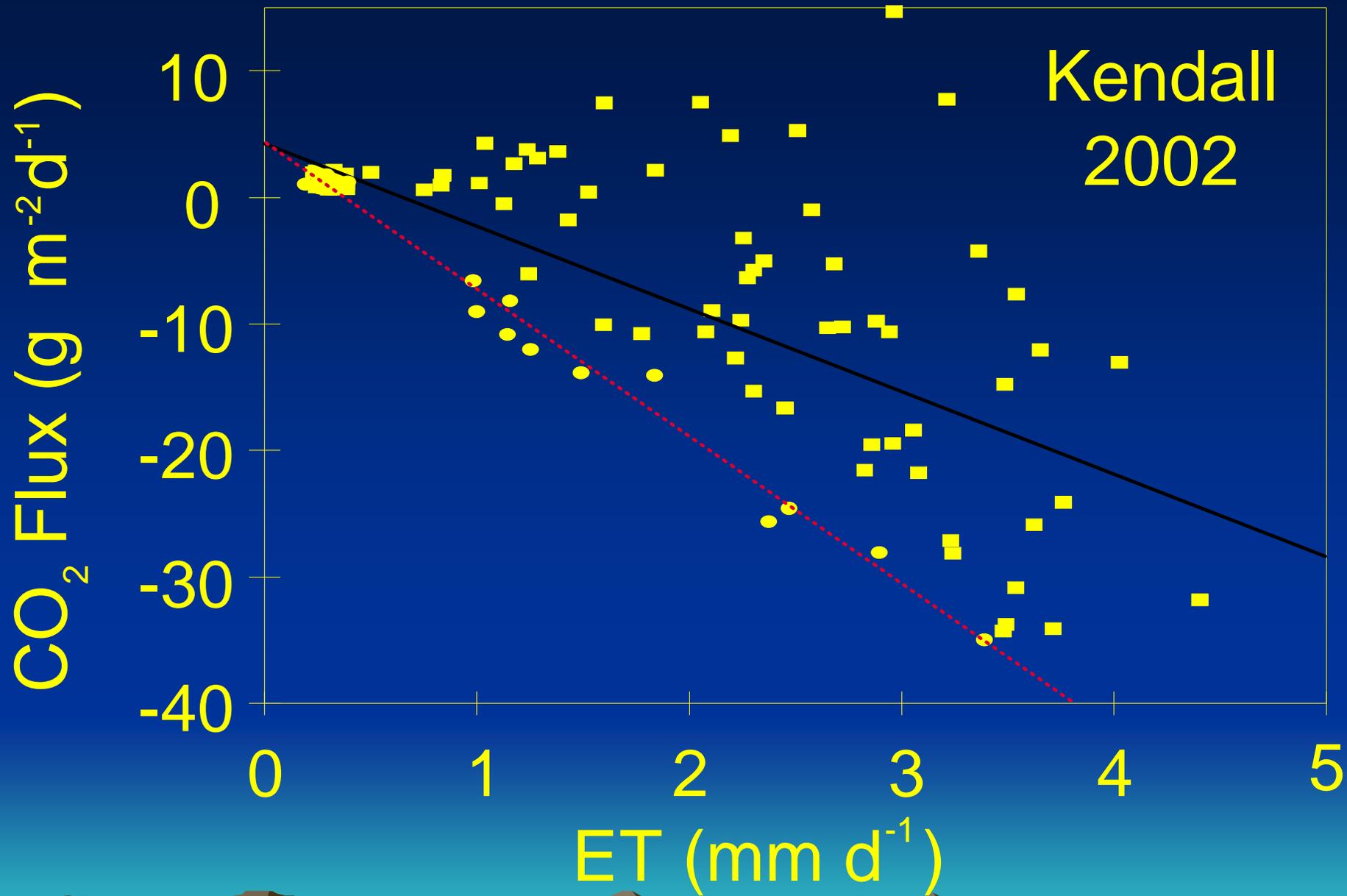
$\text{CO}_2$  Flux ( $\text{g m}^{-2} \text{d}^{-1}$ )

Lucky Hills 1998

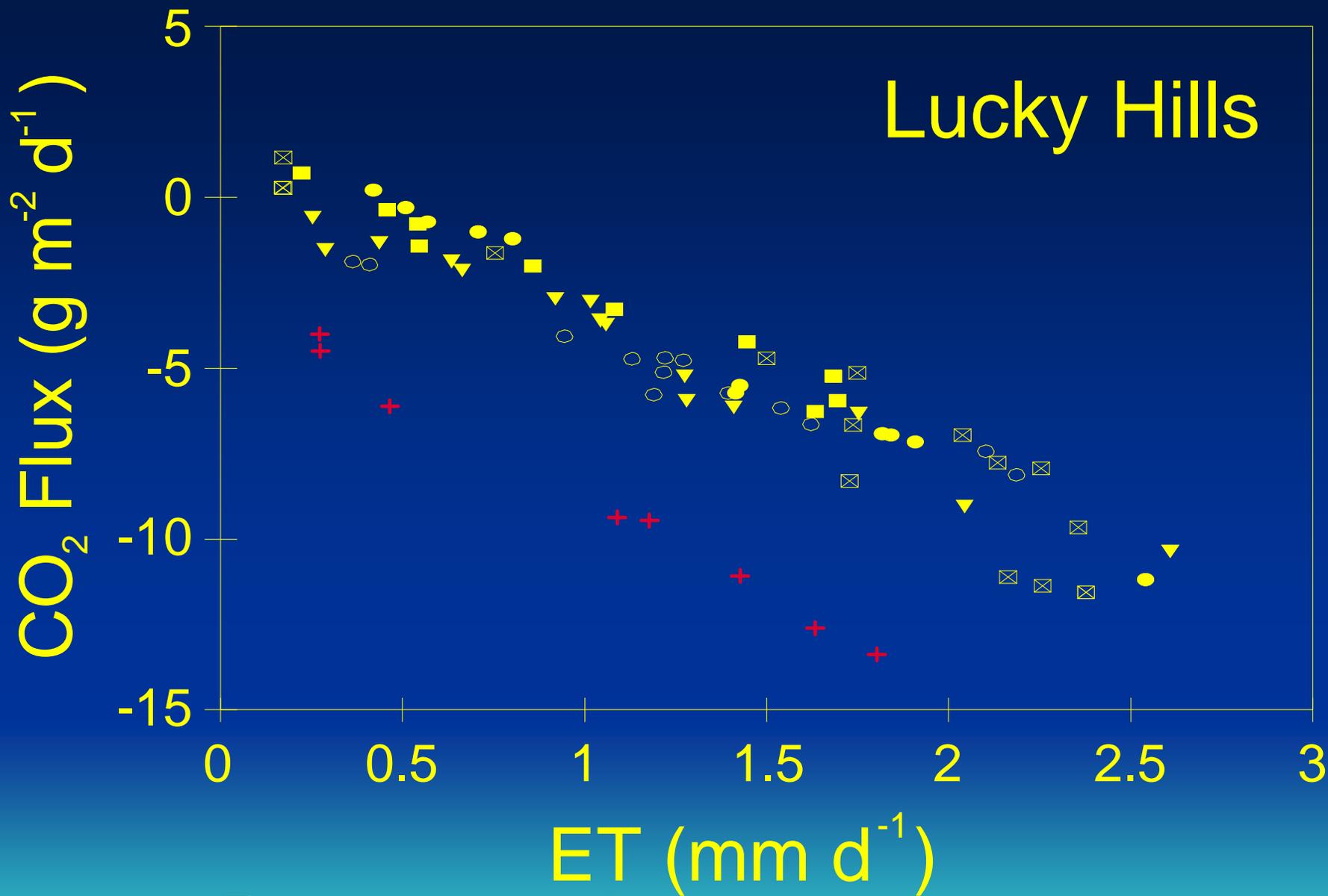


ET ( $\text{mm d}^{-1}$ )





# Lucky Hills



CO<sub>2</sub> Flux (g m<sup>-2</sup> d<sup>-1</sup>)

0  
-10  
-20  
-30  
-40

0 1 2 3 4 5 6

ET (mm d<sup>-1</sup>)

Kendall



# REGRESSION COEFFICIENTS AND SLOPE FOR LUCKY HILLS (CO<sub>2</sub> FLUX VS ET)

Year	$r^2$	Slope
1998	0.23	-1.4
1999	0.58	-3.2
2000	0.39	-2.9
2001	0.06	-1.5
2002	0.39	-2.7
2003	0.18	-1.5
<b>Average</b>	<b>0.31</b>	<b>-2.2</b>



# MAXIMUM REGRESSION COEFFICIENTS AND SLOPE FOR LUCKY HILLS (CO<sub>2</sub> FLUX VS ET)

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Year	r <sup>2</sup>	Slope
1998	0.97	-4.3
1999	0.96	-4.3
2000	0.99	-5.3
2001	0.99	-5.9
2002	0.91	-5.0
2003	0.96	-3.4
<b>Average</b>	<b>0.96</b>	<b>-4.7</b>



# REGRESSION COEFFICIENTS AND SLOPE FOR KENDALL (CO<sub>2</sub> FLUX VS ET)

Year	r <sup>2</sup>	Slope
1998	0.36	-3.0
1999	0.52	-4.5
2000	0.40	-2.4
2001	0.25	-2.2
2002	0.52	-6.5
2003	0.10	-0.5
<b>Average</b>	<b>0.36</b>	<b>-3.2</b>



# MAXIMUM REGRESSION COEFFICIENTS AND SLOPE FOR KENDALL (CO<sub>2</sub> FLUX VS ET)

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Year	r <sup>2</sup>	Slope
1998	0.99	-6.3
1999	0.98	-6.3
2000	0.90	-6.5
2001	0.98	-5.2
2002	0.98	-11.6
2003	0.97	-8.2
<b>Average</b>	<b>0.97</b>	<b>-7.4</b>



# SUMMARY OF REGRESSION COEFFICIENTS (CO<sub>2</sub> FLUX VS ET)

	$r^2$	Slope	Maximum	$r^2$	Slope
Lucky Hills	0.31	-2.2	0.96	-4.7	
Kendall	0.36	-3.2	0.97	-7.4	



# CARBON DIOXIDE FLUX DIVIDED BY ET FLUX

(g CO<sub>2</sub> m<sup>-2</sup> mm<sup>-1</sup> ET)

Year	Lucky Hills	Kendall
1998	0.21	-1.65
1999	-1.39	-2.21
2000	-0.69	-1.36
2001	-4.21	-1.80*
2002	-0.45	-3.81
2003	-1.15	0.38
<b>Average</b>	<b>-1.28</b>	<b>-1.74</b>

\*2001 data not in average missing ET data.



# ABOVEGROUND GROWING SEASON BIOMASS DIVIDED BY ET (g C m<sup>-2</sup> mm<sup>-1</sup> ET)

Year	Lucky Hills	Kendall
1998	-0.41	-0.07
1999	-0.08	-0.15
2000	-0.08	0.07
2001	0.0	-1.97*
2002	0.0	-0.18
2003	-0.10	-0.32
<b>Average</b>	<b>-0.11(-0.31)</b>	<b>-0.13(0.93)</b>

\*2001 data not in average missing ET data.



# SUMMARY OF ANALYSIS METHODS

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	Lucky Hills	Kendall
Regression (CO <sub>2</sub> FLUX VS ET)	-2.2	-3.2
Regression Maximum	-4.7	-7.4
Flux Ratio (g CO <sub>2</sub> m <sup>-2</sup> mm <sup>-1</sup> ET)	-1.28	-1.74
Biomass vs ET (g C m <sup>-2</sup> mm <sup>-1</sup> ET)	-0.31	-0.93

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# SUMMARY

1. KENDALL IS MORE ECOSYSTEM WATER USE EFFICIENT (EWUE) THAN LUCKY HILLS
2. DEPENDING ON METHOD OF EVALUATION KENDALL IS 1.4 TO 3.0 TIMES MORE EWUE THAN LUCKY HILLS



# Present & Future Research

- SEPARATION OF ORGANIC AND INORGANIC CARBON FLUXES
- EVALUATION OF ET AND WATER BALANCES
- SCALING OF POINT MEASUREMENTS OF CO<sub>2</sub> & ET TO LARGE SCALES WITH REMOTE SENSING
- MODELING CO<sub>2</sub> & ET FLUXES

